Compensatory Mitigation Plan for the for the ECHO Cable Landing Piti, Guam:

Crown-of-Thorns Starfish Removal

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AP	articulated pipe
COTS	crown-of-thorns starfish
DAWR	Division of Aquatic and Wildlife Resources
GPS	global positioning system
HEA	Habitat Equivalency Analysis
NMFS	National Marine Fisheries Service
sq. ft	square feet
sq. m	square meter
USACE	U.S. Army Corps of Engineers

1. INTRODUCTION

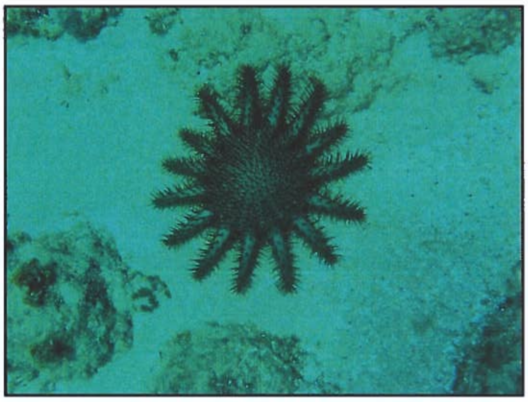

Figure 1. *Acanthaster planci* starfish in Piti.

The purpose of this Compensatory Mitigation Plan is to describe the proposed methods to offset the potential impacts to approximately 47.99 square feet (sq. ft.) (4.46 square meters (sq. m)) of shallow hardbottom that would result from the proposed ECHO cable landing project in the Tepungan Channel in Piti, Guam. The Plan proposes methods to remove a target number of crown-of-thorns starfish (COTS) (*Acanthaster planci*) from Guam's reefs (Figure 1).

The removal of COTS is proposed as mitigation since outbreaks of these coral predators are a significant cause of coral loss, and a loss of the habitat and structure provided by live coral reefs directly affects reef fish and other reef-dependent species (Hoot, 2017).

Coral resources directly impacted by the cable landing that fall within the relocation criteria (e.g., water depth shallower than 100 ft and smaller than 50 cm or approximately 20 inches) will be removed from the substrate and translocated to a suitable recipient site (Duenas, Camacho & Associates, Inc., 2021). Corals that do not meet the relocation criteria will be left in place, although some corals are expected to recover and continue to grow.

The goal of this compensatory mitigation plan is to provide additional mitigation for the potential loss of coral resources directly impacted by the cable landing that cannot be relocated.

1.1 Description of Proposed Action

The single ECHO fiber-optic submarine cable will be landed through one of the existing conduits at its seaward opening in the previously installed bulkhead and marine raceway on the Tepungan reef flat. The cable will be pulled through the buried conduit to shore, where it will be spliced to land cables in the existing buried beach manhole located above the high tide line (HTL) within Lot 58-1-NEW-1-1NEW, located east of Pedro Santos Memorial Park in Piti. The cable would be laid directly on the seabed starting from the bulkhead and proceeding seaward. Once the cable is verified to be in the correct and intended alignment, divers will install articulated pipe (AP) around the cable to a seaward distance of 799 m, around the 25 m (82 ft) depth contour. Once the AP installation is complete, the cable will be selectively pinned to the seabed in 20 locations where no live coral exists.

1.2 Description of Impacts from Proposed Action

The impact of the cable-laying activity would be related to the footprint of the cable crossing over hardbottom substrate containing coral reef habitat. The cable footprint varies depending on the type of cable and whether articulated pipe protection would be used over that section of cable. Three types of cable would be used within three (3) nautical miles of the mean high water mark:

- double-armored shielded (DAS) cable with a 4.1 cm (1.61 inch) diameter;
- single-armored (SA) cable with a 2.8 cm (1.10 inch) diameter; and
- light-weight shielded (LWS) cable with a 2.7 cm (1.06 inch) diameter.

The more resilient DAS cable would be laid 1.914 km (1.18 mi) from the bulkhead (or 2,028 m from the MHW mark) out to the approximately 343 m (1,125 ft) depth where the cable type would then transition to SA cable. After a distance of approximately 7.94 km (4.93 mi), the cable would transition from SA cable to LWS cable at the 1,000 m (3,281 ft) depth. LWS cable would be laid approximately 1.597 km (0.99 mi) where it would cross the 3 nm limit at the 1,807 m (5,928 ft) depth.

Articulated pipe (15.1 cm or 6.1 inch diameter) would be placed over the DA cable starting from the bulkhead to a seaward distance of 799 m (2,622 ft) and pinned to the seabed at approximately 20 locations onto hard substrate where there are no live corals. The U-bolt pins will be stainless steel with typical dimensions of 14 in. long, 5 in. wide, and 0.5 in. diameter (38 cm long, 12.7 cm wide, and 1.2 cm diameter).

The DAS cable with articulated pipe would have a disturbance footprint of approximately 0.50 ft or 6 inches (0.15 m) wide and would be laid over 247 m (810 ft) of shallow hardbottom substrate. The holes drilled in the hardbottom substrate would cover approximately 0.304 sq ft (0.0283 sq m). The combined total footprint of DAS cables, articulated pipe, and 20 pins would occupy approximately 412 sq. ft or 0.009 acres over shallow hardbottom substrate supporting coral reef areas with up to approximately 15.9% mean coral cover in the seaward slope zone, or a maximum estimated coral cover of 23.3% based on individual transects in the seaward slope zone (Burdick, 2021). This is the estimated permanent impact area over shallow hardbottom substrate supporting coral reef habitat from the cable-laying activity.

While corals will be avoided to the maximum extent practicable through pre-marking of the landing route, where corals are not avoidable, they would be impacted by the weight of the cable and articulated pipe placed over or adjacent to the coral colony. There would be localized damage to coral tissue by this activity; however, based on observations of other existing cables on the seabed and depending on the species involved, it is anticipated there is a good likelihood that the coral would eventually recover and grow around the cable.

- Direct but temporary impacts from cable landing.
  There is the possibility that divers would make inadvertent contact with the seabed during the cable landing, AP installation, and pinning activities. All divers working in the marine environment would be briefed on the presence of fragile coral colonies and best management practices on how to avoid impacts to marine resources. During the AP installation, divers may stage the AP segments next to the cable on the seabed. Staging will be conducted in such a way that no corals are impacted by manually placing the AP segments on areas where no live corals exist.

- Direct and permanent impacts from cable-laying portions.
  The total footprint of DA cable, articulated pipe, and 20 pins would occupy approximately 411.98 sq. ft over shallow hardbottom substrate supporting coral reef areas with a mean coral cover of 15.9% and a maximum cover up to approximately 23.3% for the seaward slope zone (Burdick, 2021). This is the estimated permanent impact area over hardbottom substrate supporting coral reef habitat from the cable-laying activity. The remaining cable-laying portions cross over deep hardbottom substrate at greater than 80 ft depth where coral cover is anticipated to be lower. The cable in these deeper areas would have smaller (4.1 cm or 1.61 inch) footprints because no articulated pipe or pins would be used, and only the bare cable would be laid in place.

- Indirect and temporary impacts from cable-laying portions.
  A total of 20 U-bolt pins will be installed over the articulated pipe in areas of hard substrate where no living coral is present to prevent the cable's lateral movement. A 3 cm diameter hole for each side of the U-bolt pin will be drilled down to 30 cm with a hydraulic drill, and the bolts will be inserted and secured in place with a non-toxic marine epoxy. The sediment generated from this activity is anticipated to be very small, approximately 0.056 gallon per hole, or a total of 2.24 gallons (0.011 cu yds) for all 40 holes. There would be a direct and permanent impact to the rock substrate from the drilling activity, and an indirect and temporary impact from the release of minor amounts of sediment for each hole drilled. It is anticipated that this sediment would quickly disperse into the water column and have an insignificant effect on live corals, if any, in the vicinity.

- Direct but temporary impacts within reef flat corridor where the support vessels and personnel will be tracking back and forth.
  An entrance and exit corridor will be defined using floats over the existing conduit raceway to allow for small support vessels and pedestrian traffic to enter and exit the marine environment. This portion of the Tepungan reef flat is a previously disturbed and largely uncolonized area of consolidated hardbottom and unconsolidated sand, rubble, and boulders. Support vessels would be manually moved or walked over the reef flat and within the corridor to the bulkhead, where they would proceed seaward under their own power. This entrance corridor would remain in use for the entirety of the project, including AP and pin installations. A Boat Exclusion Zone will be defined

for sensitive areas for the Tepungan reef flat where other coral mitigation sites from past cable landings are present.

2. MITIGATION OBJECTIVES AND PERFORMANCE

2.1 Functions to be Lost at Impact Area

The landing of the ECHO submarine cable is anticipated to result in the loss of ecological functions and services associated with coral reef habitat from the following impacts:

- Direct long-term physical impacts and temporary physical impacts and water quality impairments, including an increase in turbidity and sedimentation, during the project.
- Adverse effects to essential fish habitat (EFH) and management unit species (MUS) because there will likely be permanent loss, or long-term damage to, coral colonies/coral reef living on hardbottom substrate in the project area.

This compensatory mitigation plan is prepared to offset adverse effects to EFH (i.e., benthic/bottom habitat and substrate) and MUS resources (i.e., coral colonies/coral reefs that are coral reef ecosystem MUS (CRE-MUS)) and their ecosystem function due to the laying of the cable, AP installation and pinning activities.

2.2 Quantifying Impacted Marine Resources

Benthic cover estimates were derived by Burdick (2021) from point-count analysis of photographic images captured along a series of transects laid end-to-end across the length of a 10 m wide survey corridor from the bulkhead to the mouth of Tepungan Bay. Most benthic photo transects were 50 m long, but a 22 m-long section of corridor that extended from the base of the seaward slope (about 25 m depth) to a depth of 20 m was surveyed by obtaining photos at estimated 1 m intervals in order to reduce nitrogen loading in the dive team by limiting time spent below the 20 m depth. Benthic cover estimates were generated through an analysis of the photo transect images using Coral Point Count with Excel Extension (CPCe) application. Corals were identified to species when possible, although some taxa, such as massive *Porites*, *Montipora*, and others, often could not be identified to species level using the photo transect images.

Burdick's (2021) survey corridor crossed three major reef zones:

- a deeper (40-25 m deep) sand channel zone (approximately 130 m long) with no coral cover, comprised entirely of sand with no hardbottom habitat;
- a moderate depth (25-5 m deep) seaward slope zone (approximately 210 m long) characterized by moderate-to-high relief hardbottom aggregate reef (93%), limited sand substrate (7%), and moderate coral cover;

• and a shallower (approximately 15-4 m deep) channel zone (approximately 560 m long) comprised primarily of unconsolidated sediment with occasional patches of hardbottom, with low-to-no coral cover.

Hard coral mean benthic cover on hardbottom substrates was relatively low to moderate ranging from 0% in the deep channel (40-25 m depth), to 15.9% on the seaward slope (25-5 m depth), and 0.2% in the shallow channel (approximately 15-4 m depth) (Burdick, 2021).

2.3 Functions to be Gained at Impact Area

The main goal of this mitigation plan is to compensate for the loss of ecological functions and services from the landing of a single cable over a total of 411.98 sq. ft (0.009 acres or 38.27 sq. m) of shallow hardbottom. The coral cover over these areas ranges from 0.1% in the shallow channel up to 23.3% in the seaward slope based on individual transects (Burdick, 2021). Out of an abundance of caution, the upper limit of coral cover (23.3%) was selected to calculate that the cable could affect an estimated total of 95.99 sq. ft. (8.92 sq. m) area of impacted coral resources (total hardbottom footprint multiplied by the maximum coral cover percentage). Approximately 50% of this impacted area (47.99 sq. ft or 4.46 sq. m) would be mitigated by the post-landing coral relocation by experienced biologists (DCA, 2021). A post-landing survey would evaluate those corals affected by the cable landing activities, e.g., by shading or abrading, and then relocate those corals to an area with similar habitat conditions.

The remaining 50% of this impacted area (47.99 sq. ft or 4.46 sq. m) would be mitigated by the proposed removal of COTS from Guam's reefs, as described in this mitigation plan. The Piti Bay area is among the hotspots where diffuse COTS outbreaks have been documented in past years (Personal communication, Valerie Brown, NMFS), including COTS observed during the monitoring of relocated corals for previous cable landings (DCA, 2018). The removal of COTS in Piti Bay would prevent the further loss of live coral cover by an aggressive coral predator, which can individually consume between 5 and 13 sq. m of reef per year (Dixon, 1996). This mitigation action would allow existing corals to recover, and therefore, would contribute toward the restoration of habitat and structure of the reef ecosystem. These functions of habitat and structure to be regained by restoration of live coral reefs directly affect reef fish and other reef-dependent species (i.e., EFH and CRE-MUS).

3. MITIGATION WORK PLAN

This section describes the proposed work plan for the removal of a target number of COTS from Guam's reefs. The information was sourced from guidance documents prepared by experienced resource managers, such as the *Crown-of-Thorns Starfish Control Guidelines* (Great Barrier Reef Marine Park Authority, 2017), and from Ms. Valerie Brown, National Marine Fisheries (NMFS).

On Guam, the injection solution of choice for COTS removal is a 10 milliliter (ml) dose made from ox bile salts (10 grams salt to 1 liter of water), which is administered *in situ* by a metal applicator into the base of a COTS arm. Ox bile has proven more effective than household vinegar, which requires three times more solution than ox bile salts; the ox bile solution also results in reliable mortality (100%) of COTS within 12 hours after injection (Personal communication, Valerie Brown, 15 October 2018). Since the ox bile injection is presumed to be lethal, and has been confirmed in laboratory and field trials, there is no need to wait to confirm mortality after injection if the solution is applied correctly.

Bile salts (sodium cholate $C_{24}H_{39}NaO_5$ (NaC) and sodium deoxycholate $C_{24}H_{30}NaO_4$ (NaD)) are derivatives of bile collected as a by-product from cattle during the standard abattoir process; therefore, cattle are not killed specifically for bile salts (Great Barrier Reef Marine Park Authority, 2017). Laboratory and field surveys showed no immediate flow-on effects on reef fish, corals, and other benthic invertebrates from the injection of COTS with an ox bile salt solution (Great Barrier Reef Marine Park Authority, 2017).

On the Great Barrier Reef, decomposition of COTS was complete within four days after injection with a bile salt solution, and it is anticipated that any residual ox bile is likely to be broken down by free-living marine bacteria (Rivera-Posada et al., 2014). In controlled settings, the whitetail damselfish (*Pomacentrus chrysurus*) and moon wrasse (*Thalassoma lunare*) were the most common of the 14 fish species to approach or feed on the remains of COTS injected with the ox bile salt solution (Rivera-Posada et al., 2014). It is anticipated that the COTS injected in Guam's reefs under this mitigation plan would similarly decompose or be fed upon by reef fish within a few days.

3.1 Field Methodology

The dive team will consist of two divers: one to inject the bile salt solution into any observed COTS, and one to record the size and number of COTS injected and take photographs. The ox bile salt solution should be mixed in advance and the reservoir filled. Since the solution is clear, it is recommended to add a small amount of red food coloring to the solution as a visual aid when injecting the COTS. The photographs in Figures 2 through 4 show the equipment needed for COTS removal.

The work would proceed as follows:

1. On the boat, the biologist will assemble the bile salt applicator (**Figure 2**) and reservoir (**Figure 3**) and place the lance and needle into the COTS Hook (**Figure 3**) to avoid injuries while not using the applicator.
2. Attach bile salt reservoir to weight belt or scuba buoyancy compensator device (BCD).
3. Enter the water cautiously. Once in the water, the biologist will take a global positioning system (GPS) point to record the approximate starting location.
4. Prime the COTS applicator by pumping the handle until a small amount of bile salt solution exits the needle.
5. Proceed in a designated search pattern (e.g., ladder or expanding square pattern) searching for signs that COTS may be present (e.g., fresh feeding scars on coral colonies). Fresh feeding scars typically indicate that the COTS is within 4 meters of the scar.
6. Once a COTS has been located, estimate the size class and record it on the data sheet (Exhibit A).
7. Take a photograph of the specimen with the COTS Hook nearby for scale.
8. Inject the COTS in the base of one of the arms, if possible. Otherwise, inject another location; however, it will take longer for the COTS to die.
    a. Insert the needle slowly and gently, ensuring the needle does not go through the COTS.
    b. Pull the injector handle slowly to allow the full dosage to be injected.
    c. If bile salt solution is observed leaking into the marine environment, stop the injection and inject a different arm.
    d. COTS with a size class of greater than 40 cm require 2 injections.
9. Continue to search for and inject COTS until any diver reaches 1,000 pounds per square inch (psi) of air in their scuba tank.
10. Before surfacing, place the COTS applicator needle into the COTS Hook to avoid injury.
11. On the surface, take another GPS point to record the approximate ending location.
12. Once safely on the boat, remove the reservoir and carefully store the COTS applicator.

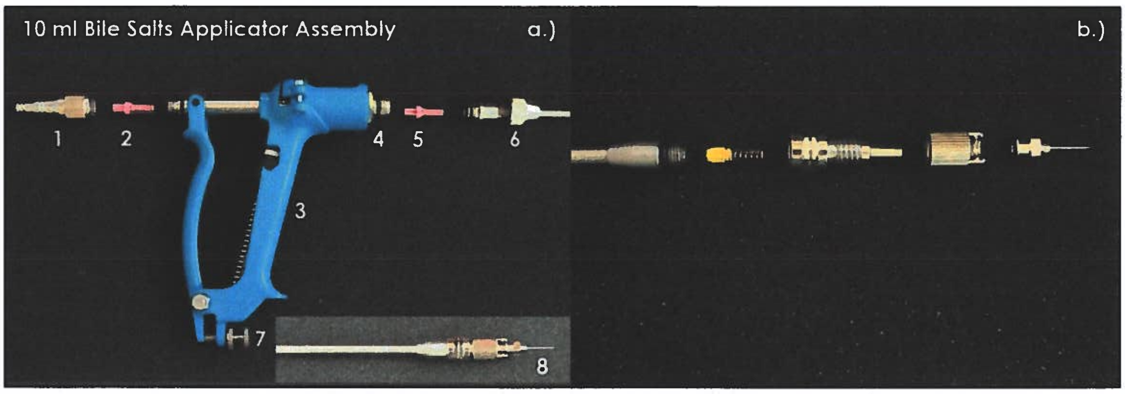

Figure 2. Assembly of the COTS applicator.

Left Photograph a) 1 - inlet adaptor, 2 - inlet valve assembly, 3 - hand piece, 4 - delivery valve cage, 5 - delivery valve assembly, 6 - spear nut, 7 - dose adjustor screw, 8 - lock nut and veterinary needle. Right Photograph b) Step-by-step sequence showing the correct assembly of the lock nut and the veterinary needle used in the bile salts applicator (Great Barrier Reef Marine Park Authority, 2017).

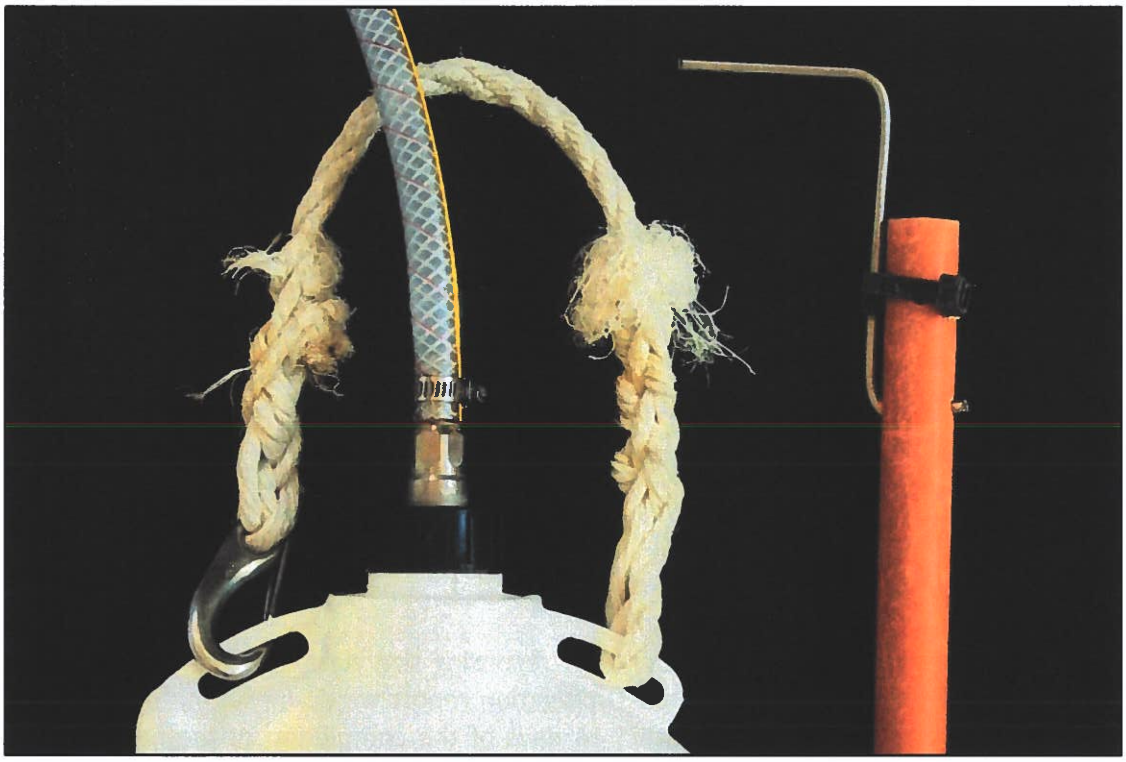

Figure 3. Hook and bottle with spliced rope and clip (Great Barrier Reef Marine Park Authority, 2017).

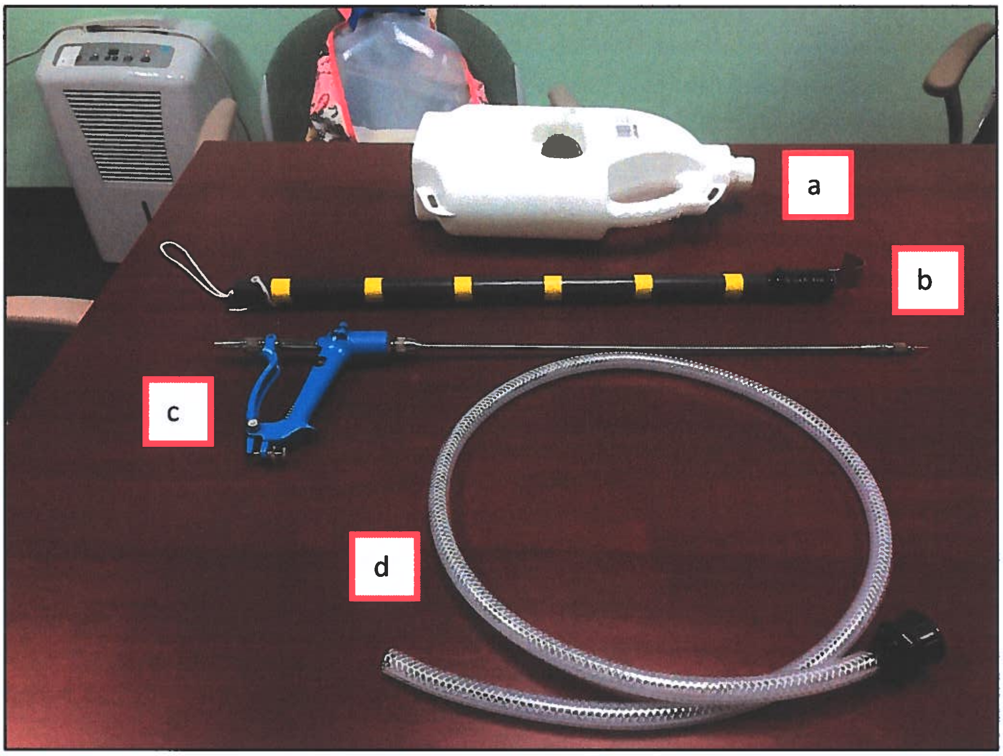

Figure 4. COTS applicator equipment.
a) reservoir for ox bile salt solution; b) COTS hook with yellow tape for measurements; c) COTS applicator; d) COTS reservoir hose.

3.2 Work Plan and Schedule

Compensatory mitigation may start once all required permits have been issued. The effort will be coordinated with NMFS and DAWR so that areas with diffuse or discrete outbreaks are targeted. Since the field portion of the mitigation effort is estimated to take only a few days, maximizing the potential and likelihood of encountering highest-possible densities of COTS is desirable.

3.3 Monitoring and Reporting

In-water monitoring would consist of recording size class, geospatial, and photographic data for all injected COTS. A post-mitigation report would be submitted to all applicable local and federal agencies within 14 days of the completion of the field portion of the mitigation effort.

4. PERFORMANCE CRITERIA

4.1 Habitat Equivalency Analysis

The number of COTS individuals needed to mitigate the cable landing's impacts was calculated using a Habitat Equivalency Analysis (HEA). The shallow hardbottom area directly impacted by the cable landing is 8.92 sq. m. (95.99 sq. ft.). Approximately 50% of the direct impacts will be mitigated by removing and relocating coral colonies in the direct path of the cable, leaving approximately 4.46 sq. m. of coral resources to be mitigated by this compensatory mitigation effort. Using a linear recovery path starting in year 2021 with a 5% annual discount rate, the total discounted square meter years of services lost would be 46.82. The annual area consumed by COTS over a year varies from 5 to 13 sq. m of reef (Dixon, 1996); a moderate annual consumption rate of 9 sq. m was used for this calculation (Personal communication, Valerie Brown, NMFS). Therefore, 46.82 divided by this consumption rate would result in 5.20 COTS. By applying a mitigation ratio of 3:1, 16 COTS (rounded up from 15.61) individuals should be removed from Guam's reefs to compensate for the cable landing's impacts to shallow hardbottom resources (Table 1).

Table 1. Habitat Equivalency Analysis Summary

Cable Impact Area (Hardbottom >30m Water Depth)	8.92	sq m
Percent Mitigated by Post Landing Coral Relocation	50%	
Adjusted Cable Impact Area	4.46	sq m
Discount Rate	5%	per year
HEA Calculated Mitigation Area	46.82	sq m
COTS Annual Coral Consumption Rate	9.00	sq m
Mitigation Ratio	3	:1
Total COTS Individuals Needed	15.61	COTS

The compensatory mitigation project will be considered successful once the 16 COTS individuals have been successfully injected with the correct amount of bile salt solution and properly documented.

4.2 Parties Responsible

RTI Solutions Inc. will be responsible for completing the mitigation for the cable landing project in Piti, Guam.

4.3 Adaptive Management Plan

If the performance criteria for this compensatory mitigation plan is not met, RTI Solutions Inc. or its agent shall prepare an analysis of the cause(s) and, if deemed necessary by the

U.S. Army Corps of Engineers (USACE), propose remedial actions for USACE approval. The remedial action will be completed as directed by USACE.

This compensatory mitigation plan will be considered a success once a minimum of 16 COTS are successfully injected with bile salt solution and properly documented within 1 year of the cable landing's completion (i.e., cable landing, AP installation, and pinning).

Since the mortality rate using ox bile salts has been proven in the laboratory and field, the method for extermination is considered sound. The potential challenges to the mitigation approach include not locating enough COTS individuals at the selected mitigation site(s) to satisfy the performance criteria. To avoid this, the strategy would be to target hot spot areas where a COTS outbreak has been reported and verified by the local resource agencies.

The Guam Coral Reef Response Team is responsible for compiling data relevant to the early warning system for COTS outbreaks, and reporting them to the response team and other stakeholders (Hoot, 2017). The *Guam COTS Outbreak Response Plan* defines an outbreak as greater than 15 COTS per hectare (Hoot, 2017). Based on this threshold, Guam experienced a diffuse COTS outbreak with densities as high as 80 individuals per hectare in all size classes, including individuals up to 45 cm in diameter, according to reports in 2018 to the Guam Coral Reef Response Team (Personal communication, Valerie Brown, NMFS).

This mitigation plan will prioritize the COTS removal effort within the direct cable landing project area in Piti Bay. However, if it is not possible or feasible to meet the performance criteria within this project area, RTI Solutions Inc. would coordinate with NMFS and the Guam Coral Reef Response Team to target the next closest areas where COTS outbreaks are located.

4.4 Financial Assurances

RTI Solutions Inc. would be responsible for the mitigation of the reef and channel sites impacted by the landing of the submarine cable. The project would be privately funded by RTI Solutions Inc. The overall responsibility for project success is with RTI Solutions Inc. Contact information for RTI Solutions Inc. is presented below:

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5. REFERENCES

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EXHIBIT A. Sample Field Data Sheet

Location: Date:

Diver Names:

Dive Number: Start Time: End Time:

Bottom Time: Max Depth: Average Depth:

COTS No.	Time	Size Class				Feeding Scars Nearby
		<15cm	15-25cm	26-40cm	>40cm	
1						
2						
3						
4						
5						
6						
7						
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